

Explanation of velocities distribution in the galaxies without the dark matter

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Аннотация

In this work, we submit the explanation of spectra of the rotary curves of galaxies on the basis of a vector theory of gravitation without regard to the dark matter hypothesis. We study the approximation of rotary curves in case of existing of the medium constant cyclic field by the example of a number of galaxies. Besides, we obtain the curves of distribution of cyclic fields in the galaxies, wherein the theoretical and experimental data is equal.

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1 Introduction

As it is well known, there is a number of observed effects, particularly the rotary curves of the galaxies, for which explanation the concept of the hidden mass, so called dark matter, is introduced [1, 2]. But there is no any direct experimental evidence of existing of such an exotic matter. In particular, last observations of the heavy WIMP-particles in the framework of the project XENON100 was negative [3]. In addition to the dark matter, there are alternative explanations of these effects connected with the modification of the Newton's law [4, 5].

In this work, we submit the explanation of spectra of the rotary curves of galaxies on the basis of a vector theory of gravitation [6]. In the framework of this theory, we assume the existence of a vector cyclic field connected with a gravitation field in much the same manner as the magnetic field is collated with the electrical one. This cyclic field supposedly determines the anomalous behavior of rotary curves.

In this article, we study the approximation of rotary curves in case of existing of the medium constant cyclic field by the example of a number of different types of galaxies. Besides, we obtain the exact curves of distribution of cyclic fields in relation to the distance to the galactic centers, wherein the theoretical and test information is practically equal.

2 The general model

We will connect the gravitational field with the 4-potential $A^i = (\varphi, c\vec{A})$, where φ - is the usual scalar potential and \vec{A} is a vector potential, and c is the speed of light. The Lagrangian of the gravitational field with account for matter has the form

$$\mathbb{L} = -A_i j^i + \frac{1}{16\pi\gamma} G_{ik} G^{ik}, \quad (1)$$

where γ is the gravitation constant, $j^i = \mu \frac{1}{c} \frac{dx^i}{dt}$ is the mass current density vector, μ is the mass density of bodies, and $G_{ik} = \frac{\partial A_k}{\partial x^i} - \frac{\partial A_i}{\partial x^k}$ is the antisymmetric tensor of the gravitation field.

The first term describes interaction of the field and matter, the second one characterizes the field without particles. As a result, we get the gravitational field equations

$$\frac{\partial G^{ik}}{\partial x^k} = 4\pi\gamma j^i. \quad (2)$$

In the stationary case, from (2) we obtain an equation for the scalar potential:

$$\Delta\varphi = 4\pi\gamma\mu. \quad (3)$$

The solution of (3) has the form

$$\varphi = -\gamma \int \frac{\mu}{r} dV. \quad (4)$$

The potential of a single particle of mass m $\varphi = -\frac{\gamma m}{r}$. Consequently the force acting in this field on another particle of mass m' is

$$F = -\frac{\gamma m m'}{r^2}, \quad (5)$$

(5) which is the Newton law of gravity. The negative sign in this expression is caused by the positive sign of the second term in the Lagrangian (2), contrary to the electromagnetic field Lagrangian.

Let us consider the field of the vector potential created by matter particles performing motion in a finite region of space with finite momenta. The motion of this kind can be considered to be stationary. Let us write down an equation for the time-averaged vector field, depending only on spatial variables.

From (2) we obtain:

$$\Delta \overline{\vec{A}} = 4\pi\gamma \overline{\vec{j}}, \quad (6)$$

whence it follows

$$\overline{\vec{A}} = -\frac{\gamma}{c^2} \int \frac{\overline{\vec{j}}}{r} dV. \quad (7)$$

The overline denotes a time average. This field can be called cyclic. The field induction is

$$\overline{\vec{C}} = \text{rot} \overline{\vec{A}} = -\gamma \int \frac{[\overline{\vec{j}} \vec{r}]}{r^3} dV = -\gamma, \frac{[\overline{\vec{p}} \vec{r}]}{r^3}, \quad (8)$$

where \vec{p} is the particle momentum and the square brackets denote a vector product.

Thus two moving particles experience (in addition to the mutual gravitational attraction) a cyclic force. The latter can be attractive or repulsive, depending on the relative direction of the particle velocities.

3 Galaxy Rotation Curves. Approximation.

Let us assume that apart from the ordinary gravity there is the said cyclic field all over the galaxy. We can make a simplifying assumption that this field has medium constant induction across the galaxy. There are probably sure changes of value of induction of a cyclic field describing by some function of distribution in each specific galaxy, but for generality of the arguments we can neglect this. Thus, let us write the condition of equality of centrifugal and centripetal forces:

$$\frac{v^2}{r} = \frac{\gamma M(r)}{r^2} + vC \quad (9)$$

where $M(r)$ - is the matter mass inside the orbit of the radius r , C - is the constant induction of a cyclic field, γ - is the gravitational constant. This is a quadratic equation relative to velocity v . Solving it we obtain:

$$v = \sqrt{\frac{\gamma M(r)}{r}} \sqrt{1 + \frac{C^2 r^3}{4\gamma M(r)}} + \frac{Cr}{2} \quad (10)$$

Distribution of the ordinary matter in the sphere of the radius r takes the form:

$$M(r) = 4\pi \int_0^r \rho(r') r'^2 dr' \quad (11)$$

where $\rho(r)$ is the matter density.

A simple model for $M(r)$ [5]

$$M(r) = M \left(\frac{r}{r + r_c} \right)^{3\beta} \quad (12)$$

where

$$\beta = \begin{cases} 1 & \text{for HSB galaxies,} \\ 2 & \text{for LSB/Dwarf galaxies.} \end{cases} \quad (13)$$

If $r \ll r_c$ the influence of a gravitation field is considerably superior to the influence of a cyclic field, and we can neglect it in the 0 - order using just the Newton's theory.

The total mass of the galaxy M we determine as

$$M = M_{stars} + M_{HI} + M_f, \quad (14)$$

Here, M_{stars} , M_{HI} , and M_f denote the visible mass, the mass of neutral hydrogen, and the mass from the skew field energy density, respectively.

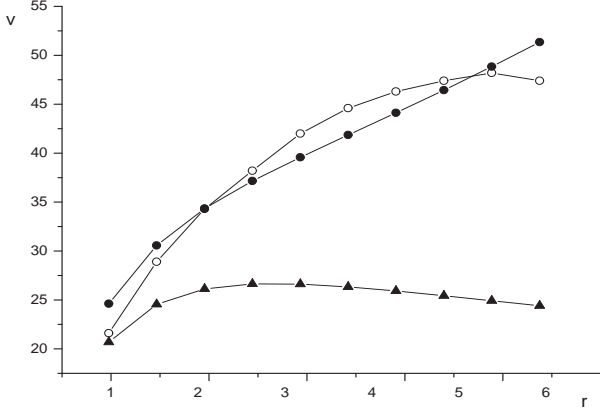


Fig.1. DDO 154; $\langle C \rangle = 2.4 \times 10^{-16}$.

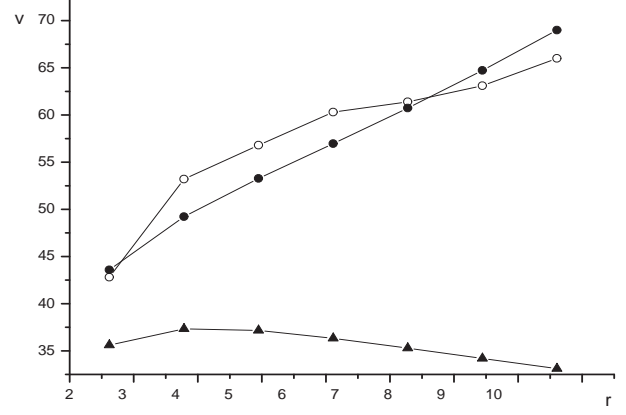


Fig.2. DDO 170; $\langle C \rangle = 1.7945 \times 10^{-16}$.

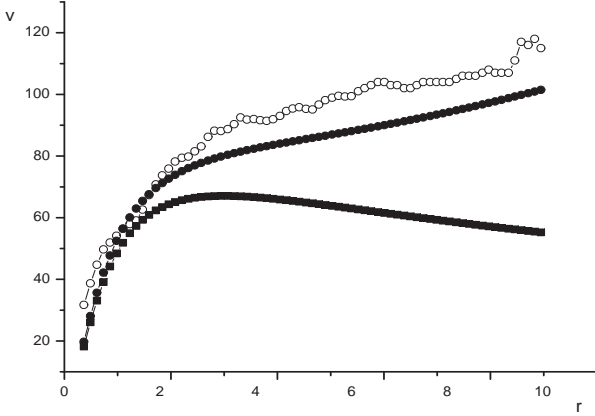


Fig.3. M 33; $\langle C \rangle = 2.59 \times 10^{-16}$.

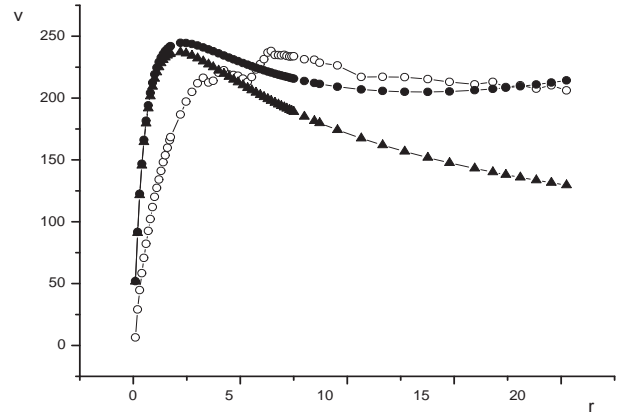


Fig.4. Milky Way; $\langle C \rangle = 1.89 \times 10^{-16}$.

In fig.1. - fig.12. there are graphs of velocity distribution in the galaxies of different types. White circles are velocity values under study, black triangles are Newtonian approximations with regard to (12), black circles are the approximations with regard to the medium constant cyclic field C obtained by the least square method. The data of velocity distribution is taken from [7, 8].

4 Galaxy Rotation Curves. Exact formula.

In the previous section, we have obtained the approximation of rotary curves of different galaxies on the assumption of existing of a medium constant cyclic field in the galaxies. It is seen that although approximation inclusive of a constant cyclic field considerably improves the Newtonian approximation, it basically has a qualitative character. The value of a medium cyclic field can be roughly connected with the average period of stars revolution T in galaxies $C \sim 2\pi/T$.

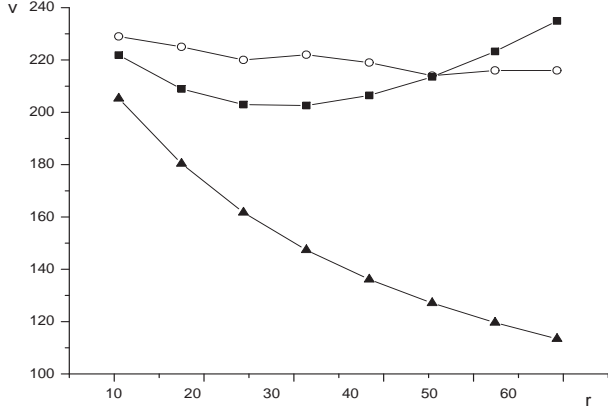


Fig.5. NGC 801 ; $\langle C \rangle = 9.865 * 10^{-17}$.

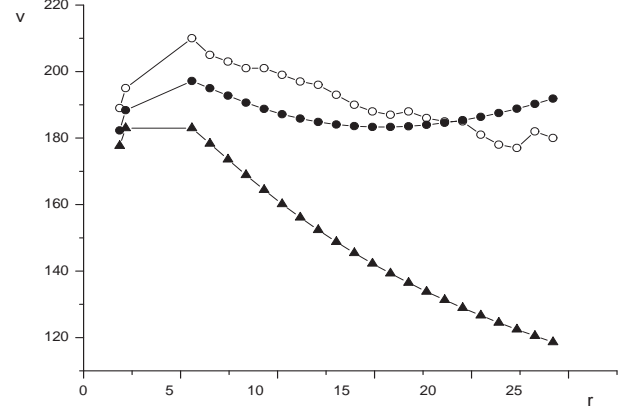


Fig.6. NGC 2903; $\langle C \rangle = 1.59 * 10^{-16}$.

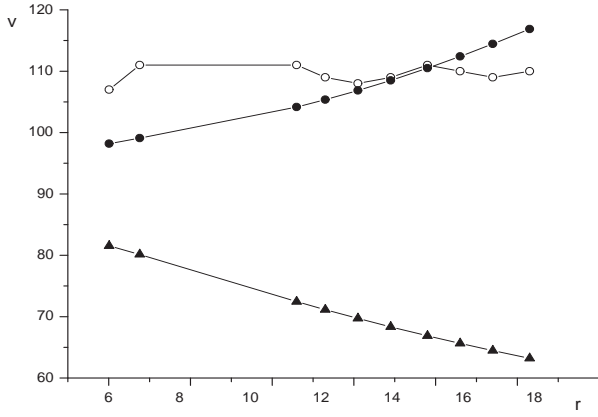


Fig.7. NGC 4183; $\langle C \rangle = 1.647 * 10^{-16}$.

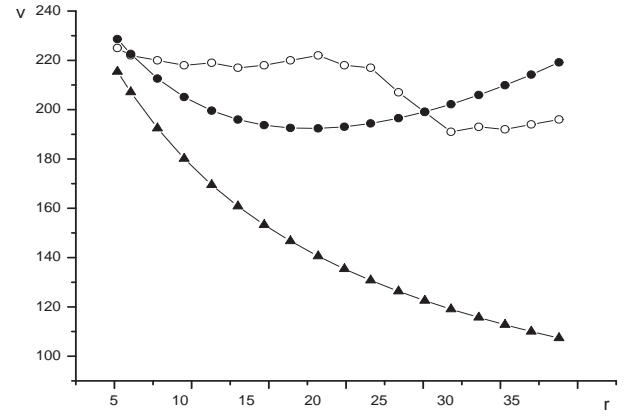


Fig.8. NGC 5033; $\langle C \rangle = 1.6 * 10^{-16}$.

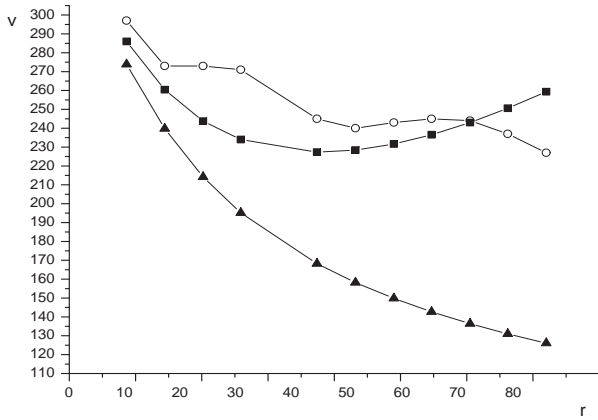


Fig.9. NGC 5533; $\langle C \rangle = 2.59 * 10^{-16}$.

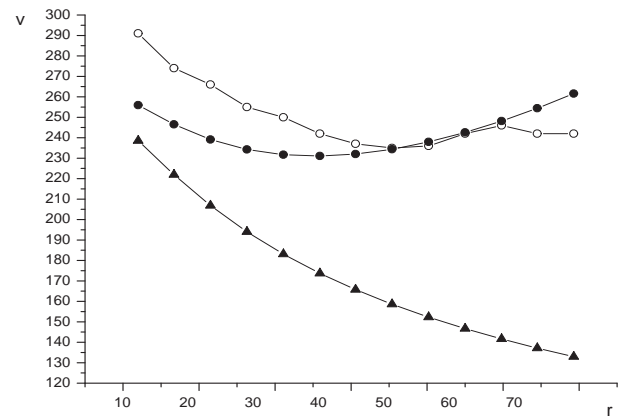


Fig.10. NGC 6674; $\langle C \rangle = 9.087 * 10^{-17}$.

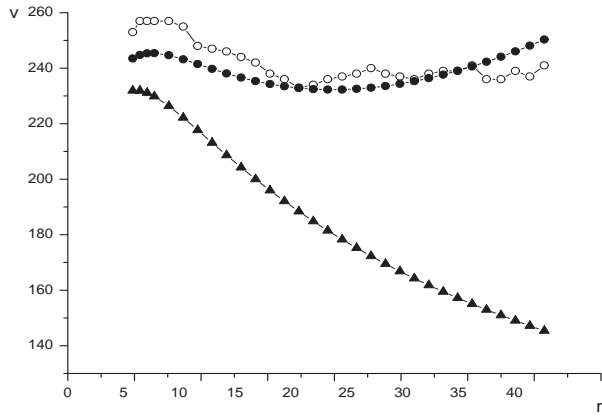


Fig.11. NGC 7331; $\langle C \rangle = 3.2 \times 10^{-16}$.

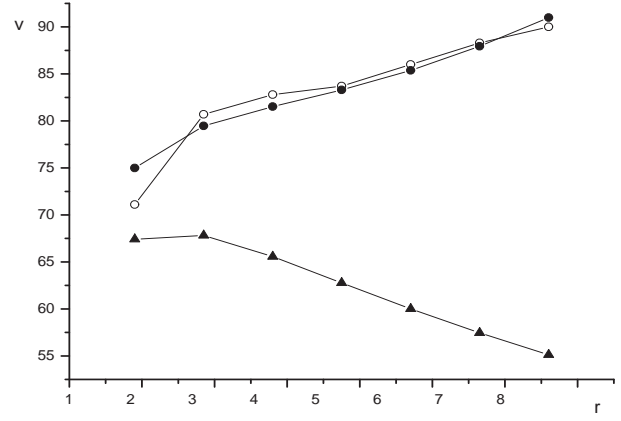


Fig.12. UGC 2259; $\langle C \rangle = 2.46 \times 10^{-16}$.

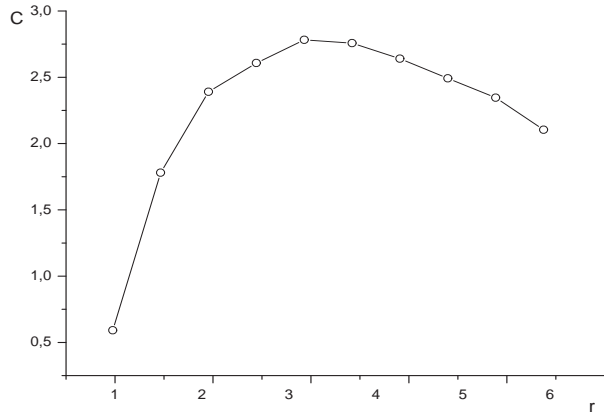


Fig.13. DDO 154;

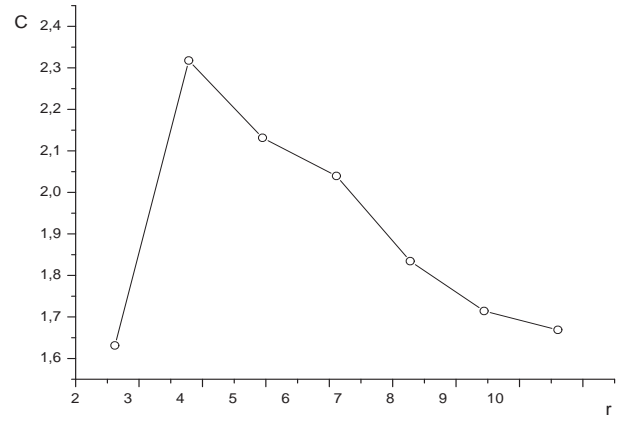


Fig.14. DDO 170;

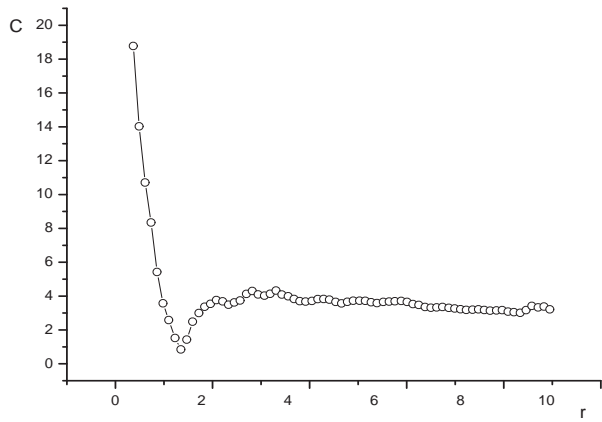


Fig.15. M 33;

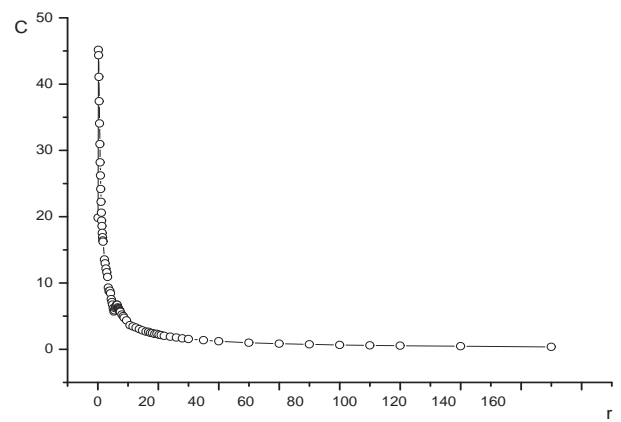


Fig.16. Milky Way;

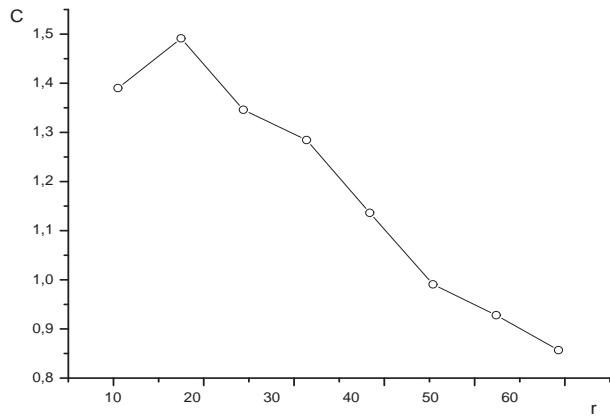


Fig.17. NGC 801;

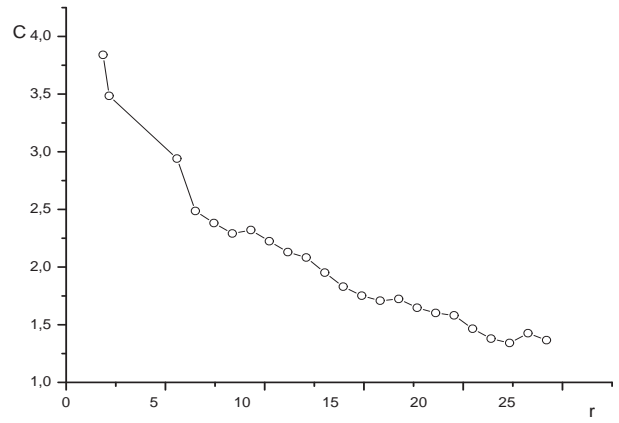


Fig.18. NGC 2903;

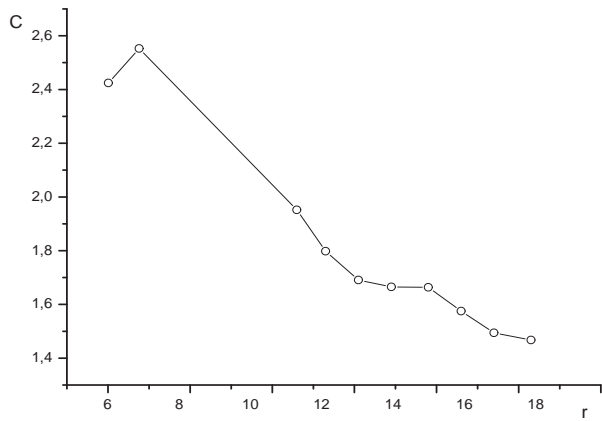


Fig.19. NGC 4183;

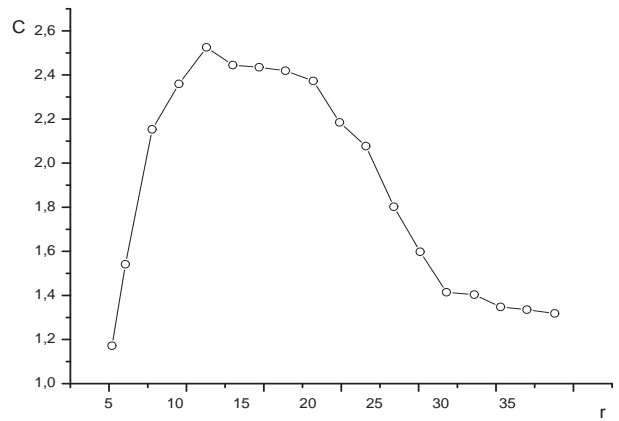


Fig.20. NGC 5033;

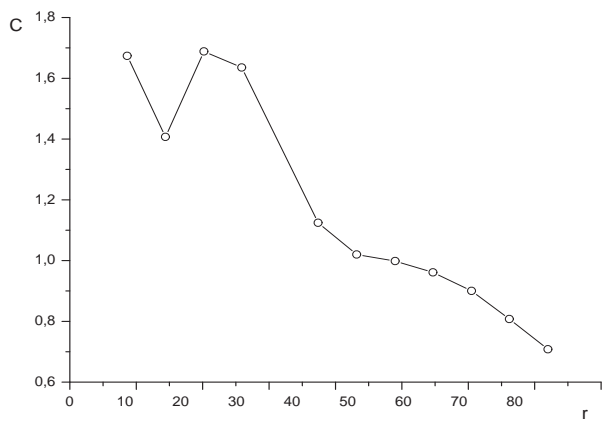


Fig.21. NGC 5533;

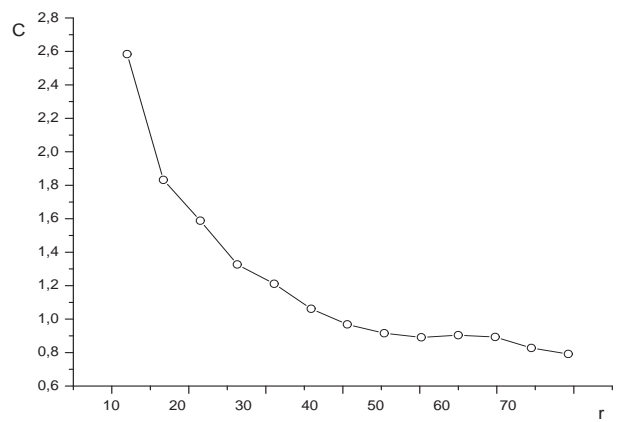


Fig.22. NGC 6674;

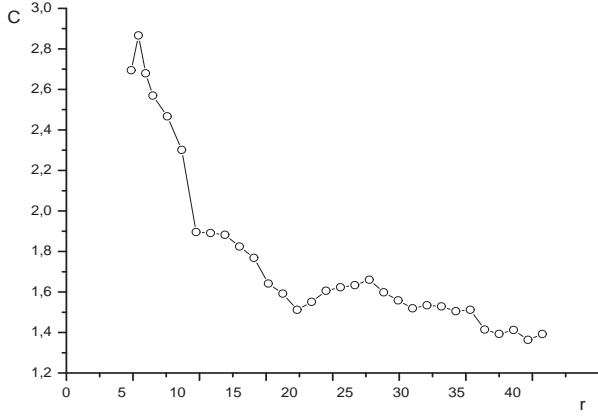


Fig.23. NGC 7331;

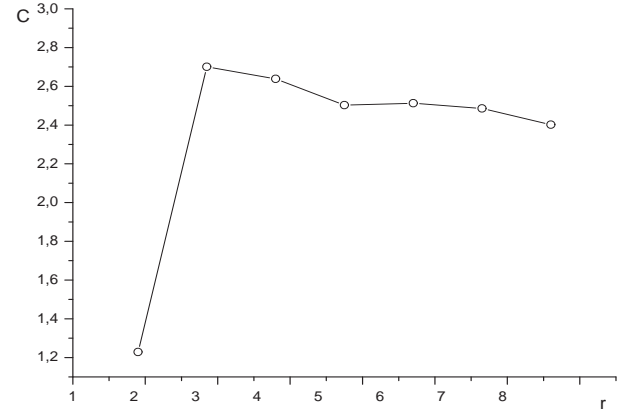


Fig.24. UGC 2259;

Таблица 1: Galaxy Properties

Galaxy	Surface Brightness	Total mass M ($10^{10} M_{sun}$)[5]	r_c (kpc) [5]
DDO 154	LSB	0.13	0.53
DDO 170	LSB	0.4	0.82
M 33	LSB	0.93	0.6
Milky Way	HSB	9.12	1.04
NGC 801	HSB	20.07	2.65
NGC 2903	HSB	9.66	1.72
NGC 4183	LSB	2.04	0.85
NGC 5033	HSB	9.9	1.1
NGC 5533	HSB	28.81	2.11
NGC 6674	HSB	32.48	3.27
NGC 7331	HSB	21.47	2.56
UGC 2259	LSB	0.77	0.48

To get a precise coincidence of the curves, it is necessary to know the type of function of cyclic field distribution in each specific galaxy. The type of such a curve for different groups of similar galaxies can be somehow selected, but using (9) we can get the exact distribution of cyclic fields with the knowledge of rotation velocities by formula:

$$C = \frac{v}{r} - \frac{\gamma m}{vr^2} \quad (15)$$

In fig.13. - fig.24. there are graphs of distribution of the cyclic fields in the same galaxies for which the approximation with regard to the medium constant cyclic field was given earlier. Thus, using values of the cyclic fields (data should be multiplied by 10^{-16}) presented in the graphs we can get the perfect coincidence of theoretical and test values of the rotation curves. Therefore, in the framework of a vector theory of gravitation [6] the type of rotary curves of the galaxies can be explained directly without necessity of introduction of the additional hypothesis of unknown dark matter.

Список литературы

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